

List of Claims

1. (previously presented) A fuel injector comprising:
 - an injector body having disposed therein a needle control chamber and a high pressure space that includes a fuel pressurization chamber;
 - an electronically controlled pressure control valve attached to said injector body;
 - a nozzle valve member with a first closing hydraulic surface exposed to fluid pressure in said needle control chamber;
 - an auxiliary valve member positioned in said injector body and being movable between an open position in which said high pressure space is fluidly connected to said needle control chamber, and a closed position in which said high pressure space is blocked to said needle control chamber, and including a second closing hydraulic surface exposed to fluid pressure in said high pressure space; and
 - a biasing spring operably coupled to bias said auxiliary valve member toward said open position.
2. (original) The fuel injector of claim 1 wherein said second closing hydraulic surface is exposed to fluid pressure in said fuel pressurization chamber.
3. (original) The fuel injector of claim 1 wherein said high pressure space includes a nozzle supply passage fluidly connected to said fuel pressurization chamber; and
said second closing hydraulic surface is exposed to fluid pressure in said nozzle supply passage.
4. (previously presented) The fuel injector of claim 1 wherein said biasing spring is a first biasing spring; and
wherein said fuel injector further comprises a second biasing spring operably positioned in said needle control chamber to bias said nozzle valve member toward a closed position.

5. (original) The fuel injector of claim 1 wherein said needle control chamber is fluidly connected to a low pressure space via a vent passage.

6. (previously presented) A fuel injector comprising:
an injector body having disposed therein a needle control chamber and a high pressure space that includes a fuel pressurization chamber;
a nozzle valve member with a first closing hydraulic surface exposed to fluid pressure in said needle control chamber;
an auxiliary valve member positioned in said injector body and being movable between an open position in which said high pressure space is fluidly connected to said needle control chamber, and a closed position in which said high pressure space is blocked to said needle control chamber, and including a second closing hydraulic surface exposed to fluid pressure in said high pressure space;
a biasing spring operably coupled to bias said auxiliary valve member toward said open position;
said needle control chamber is fluidly connected to a low pressure space via a vent passage; and
said vent passage is restrictive relative to a flow passage extending between said high pressure space and said needle control chamber.

7. (previously presented) A fuel injector comprising:
an injector body having disposed therein a needle control chamber and a high pressure space that includes a fuel pressurization chamber;
a nozzle valve member with a first closing hydraulic surface exposed to fluid pressure in said needle control chamber;
an auxiliary valve member positioned in said injector body and being movable between an open position in which said high pressure space is fluidly connected to said needle control chamber, and a closed position in which said high pressure space is blocked to said needle control chamber, and including a second closing hydraulic surface exposed to fluid pressure in said high pressure space;
a biasing spring operably coupled to bias said auxiliary valve member toward said open position; and

said needle control chamber is a closed volume when said auxiliary valve member is in said closed position.

8. (currently amended) ~~The fuel injector of claim 1 including~~ A fuel injector comprising:

- an injector body having disposed therein a needle control chamber and a high pressure space that includes a fuel pressurization chamber;

- a nozzle valve member with a first closing hydraulic surface exposed to fluid pressure in said needle control chamber;

- an auxiliary valve member positioned in said injector body and being movable between an open position in which said high pressure space is fluidly connected to said needle control chamber, and a closed position in which said high pressure space is blocked to said needle control chamber, and including a second closing hydraulic surface exposed to fluid pressure in said high pressure space;

- a biasing spring operably coupled to bias said auxiliary valve member toward said open position; and

- a cam driven plunger and an electronically controlled spill valve.

9. (previously presented) A method of increasing nozzle valve opening pressure in a fuel injector, comprising the steps of:

- setting a base valve opening pressure at least in part by biasing a nozzle valve member toward a closed position with a biasing spring;

- increasing fuel pressure in a high pressure space in the fuel injector for an injection event;

- closing a fluid connection between the high pressure space and a needle control chamber at least in part by exposing a closing hydraulic surface of an auxiliary valve member to fluid pressure in the high pressure space;

- exposing a closing hydraulic surface of said nozzle valve member to fluid pressure in the needle control chamber; and

- increasing the nozzle valve opening pressure above the base valve opening pressure at least in part by biasing the auxiliary valve member to open a fluid connection

between the high pressure space and the needle control chamber during the increasing fuel pressure step.

10. (original) The method of claim 9 wherein the fuel pressure increasing step includes the steps of:

moving a plunger into a fuel pressurization chamber of the high pressure space; and

closing a fluid connection between the fuel pressurization chamber and a drain passage with an electronically controlled spill valve.

11. (original) The method of claim 9 wherein the closing step includes a step of setting a valve closing pressure for the auxiliary valve member below the base valve opening pressure of the nozzle.

12. (original) The method of claim 9 including a step of venting the needle control chamber to a low pressure space via a restricted orifice.

13. (previously presented) A method of increasing mean injection pressure for a fuel injection event, comprising the steps of:

pressurizing fuel in a fuel pressurization chamber at least in part by actuating an electronically controlled pressure control valve;

opening a fluid connection between a high pressure space, which includes said fuel pressurization chamber, and a needle control chamber while fuel pressure is increasing in a fuel injector for an injection event;

exposing a closing hydraulic surface of a nozzle valve member to fluid pressure in the needle control chamber; and

closing the fluid connection between the high pressure space and the needle control chamber before the nozzle valve member moves from a closed position toward an open position at least in part by exposing a closing hydraulic surface of an auxiliary valve member to fluid pressure in said high pressure space.

14. (previously presented) A method of increasing mean injection pressure for a fuel injection event, comprising the steps of:

opening a fluid connection between a high pressure space, which includes a fuel pressurization chamber, and a needle control chamber while fuel pressure is increasing in a fuel injector for an injection event;

exposing a closing hydraulic surface of a nozzle valve member to fluid pressure in the needle control chamber;

closing the fluid connection between the high pressure space and the needle control chamber before the nozzle valve member moves from a closed position toward an open position at least in part by exposing a closing hydraulic surface of an auxiliary valve member to fluid pressure in said high pressure space;

pressurizing fuel in the fuel injector with the steps of:

moving a plunger into the fuel pressurization chamber; and

closing a fluid connection between the fuel pressurization chamber and a drain passage with an electronically controlled spill valve.

15. (original) The method of claim 13 including a step of venting the needle control chamber to a low pressure space.

16. (original) A method of hastening closure of a nozzle valve in a fuel injector, comprising the steps of:

setting a base closing force at least in part by biasing a nozzle valve member toward a closed position with a biasing spring;

exposing a closing hydraulic surface of the nozzle valve member to fluid pressure in a needle control chamber;

increasing a closing force above the base closing force at least in part by relieving pressure on a closing hydraulic surface of an auxiliary valve member that fluidly separates the needle control chamber from a high pressure space in the fuel injector.

17. (original) The method of claim 16 wherein said increasing step includes the step of channeling residual fuel pressure past the auxiliary valve member and into the needle control chamber.

18. (original) The method of claim 17 including a step of reducing fuel pressure in the fuel injector during the increasing step.

19. (original) The method of claim 18 wherein the reducing fuel pressure step includes a step of opening an electronically controlled spill valve.